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(71) Applicant(s)
British Broadcasting Corporation
(Incorporated in the United Kingdom)
Broadcasting House, LONDON, W1A 1AA,
United Kingdom

(72) Inventor(s)
Peter John Brightwell
Nicholas Dominic Wells
Philip Nicholas Tudor

(74) Agent and/or Address for Service
Mathys & Squire
100 Grays Inn Road, LONDON, WC1X 8AL,
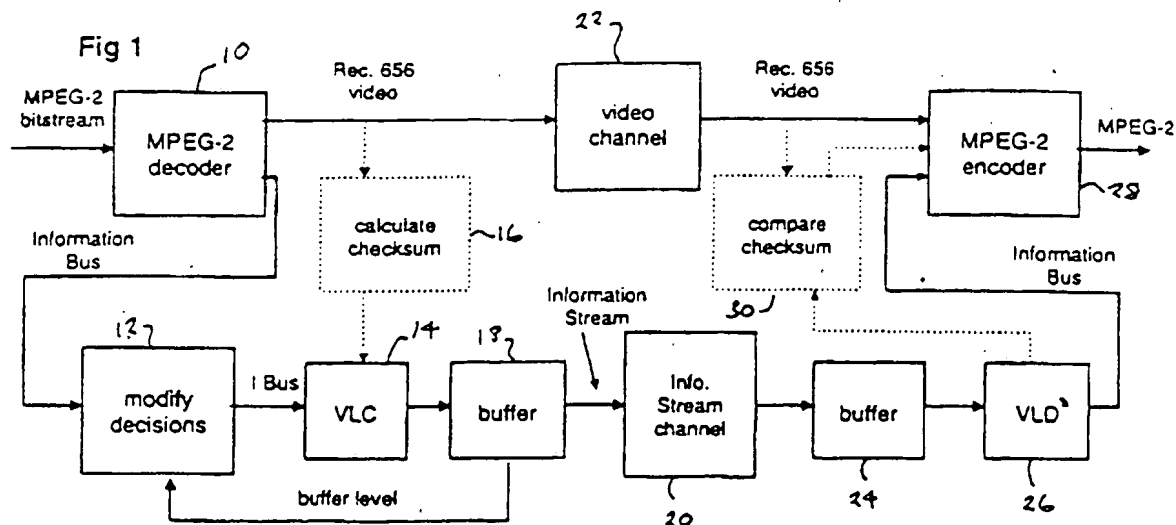United Kingdom

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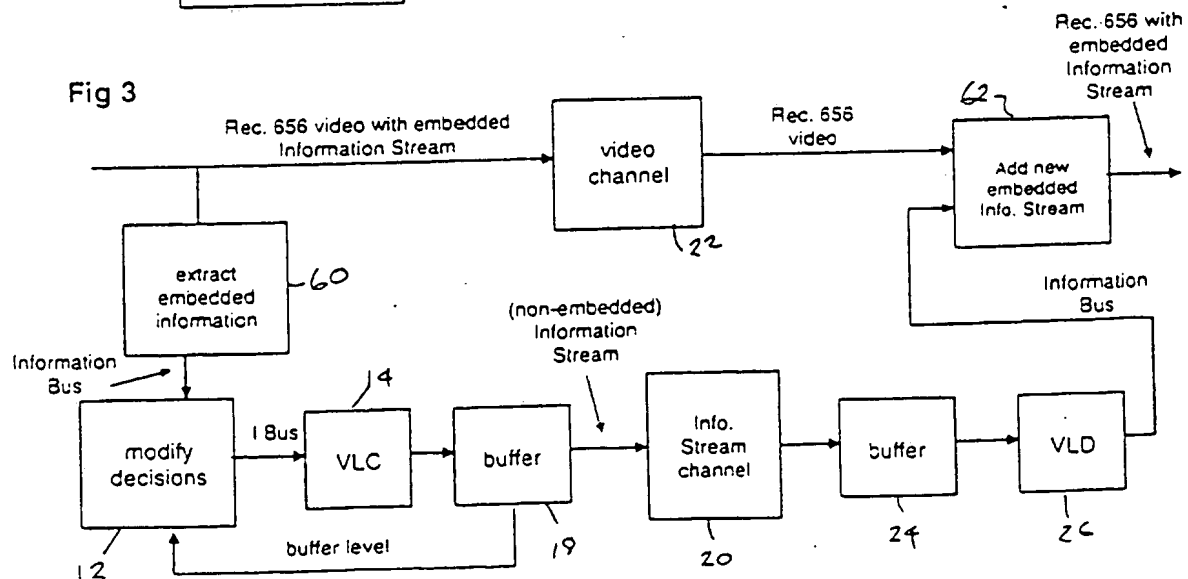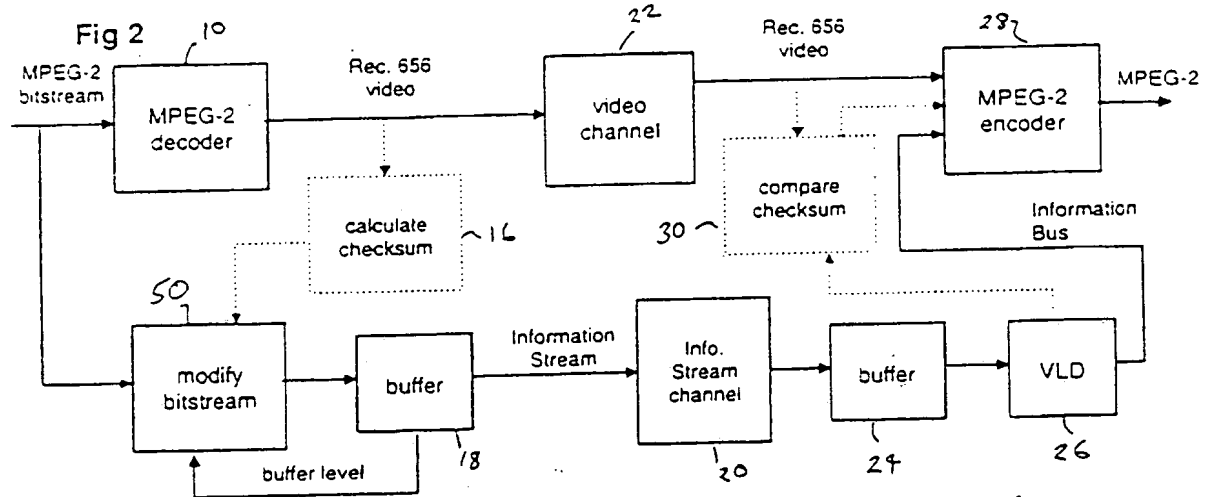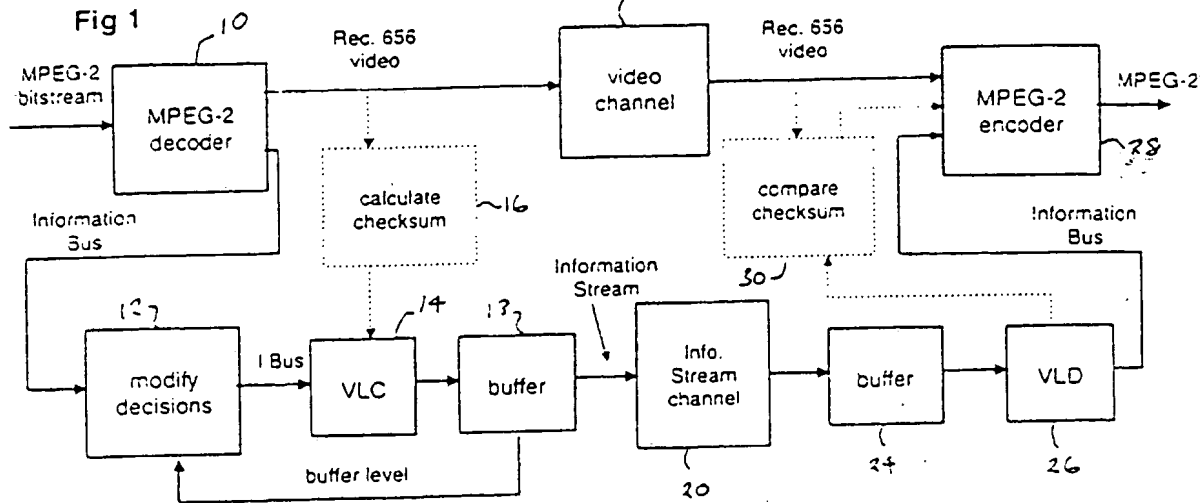(56) Documents Cited
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(54) Abstract Title
Video compression

(57) An MPEG2 decoded video signal is accompanied by a representation of the coding decisions to aid downstream re-encoding. The representation is MPEG compliant bit modified to reduce the number of bits.

Fig 1

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Fig 1

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MPEG-2 bitstream → MPEG-2 decoder → Rec. 656 video → video channel 22 → Rec. 656 video → MPEG-2 encoder → MPEG-2 28

calculate checksum ~16

compare checksum 30

Information Bus

modify decisions 12 — I Bus → VLC 14 → buffer 13 → Information Stream → Info. Stream channel 20 → buffer 24 → VLD 26

Information Stream

buffer level

Information Bus

Fig 2

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MPEG-2 bitstream → MPEG-2 decoder → Rec. 656 video → video channel 22 → Rec. 656 video → MPEG-2 encoder 28 → MPEG-2

calculate checksum ~16

compare checksum 30

modify bitstream 50 → buffer 18 → Information Stream → Info. Stream channel 20 → buffer 24 → VLD 26

Information Stream

buffer level

Information Bus

Fig 3

Rec. 656 video with embedded Information Stream → video channel 22 → Rec. 656 video → Add new embedded Info. Stream 62 → Rec. 656 with embedded Information Stream

extract embedded information 60

Information Bus

modify decisions 12 → I Bus → VLC 14 → buffer 19 → (non-embedded) Information Stream → Info. Stream channel 20 → buffer 24 → VLD 26

buffer level

Information Bus

COMPRESSED SIGNALS

This invention concerns the handling of compressed or bit-rate reduced signals.

In the most important example, this invention relates to the MPEG2 video compression system and the following description will take MPEG2 as an illustrative compression (or bit-rate reduction) system.

As compressed video increasingly find its way into the programme chain, it becomes more likely that bitstreams will be decoded and re-encoded. Examples of where this happens include switching between different bitstreams and changing between bit-rates and compression formats. It is important that unnecessary loss of quality is avoided in these cases.

There is proposed in EP-A-0 766 576 a solution in which an information bus accompanies a decoded signal and is available in a subsequent encoding process. In apparatus and channels designed for this purpose, it is possible for the decoded, picture signal to be accompanied by an information bus which contains all the side information which is contained in the MPEG signal, alongside the DCT coefficients. The information bus may also contain additional information which is related to the control of the coding or decoding process but which does not form part of the coded bitstream. It can include, for example, statistical information, information concerning errors together with instructions for use in error concealment, candidate motion vectors or recommended quantizer step sizes.

There are disclosed in co-pending international patent application PCT/GB97/01862, techniques by which an information bus can pass along a video pathway. One method uses an information bus embedded in the lowest bits of the decoded video signal (in ITU-R Rec. 656 format), such that the picture quality is not visibly affected. In one version of this, the video bits used to convey a particular coding decision are spatially and temporally locked to the area of the picture to which it corresponds. Alternatively, the information may take a different form, for instance using non-active parts of

the picture, such as the vertical blanking interval (VBI), or by using a separate channel.

A problem arises where it is not possible to embed the information bus in the video signal without suffering excessive data loss and where the equipment concerned has not been designed with an appropriate channel to carry the information bus separately. An example of this is when the video signal is recorded by a digital VTR that employs DCT-based compression, which tends to change the lowest bits of the signal.

Accordingly, the present invention consists in one aspect in a video compression system in which an encoder operates on a video signal and takes coding decisions in a compression encoding process to generate an encoded signal and in which a decoder operates on the encoded signal in a compression decoding process to generate an decoded signal, wherein a representation of the coding decisions or some of them is provided in bit-rate reduced form and accompanies the decoded signal through a bit-rate reduced channel.

The bit-rate reduced channel may take a variety of forms including one or more audio channels (such as VT audio tracks or a separate audio recorder); unused VBI lines, a video channel with significant error correction and appropriate data channels (including DVCpro data channel).

For the case of an MPEG-2 bitstream, the coding decisions typically include:

- Picture dimensions
- Frame rate
- Picture structure (frame-coded or field-coded)
- Picture type (I, P or B)
- Whether macroblocks intra-coded or use prediction
- Whether forward, backward or bi-directional prediction is used
- Whether frame-based or field-based prediction is used
- Motion vectors
- Quantiser visibility weighting matrices
- Quantiser step

- Buffer state of a decoder that is decoding the bitstream
- Information on bit-rate usage within the bitstream

When it is possible to keep *all* (or a sufficient sub-set of) the decisions
the same on recoding, it can be shown that the switch is transparent. In other
cases, such as when a new bitrate is used on recoding, it is still
advantageous to reuse many decisions (e.g. picture type and motion vectors),
and take account of others (e.g. quantiser scale).

In one form of the invention, the bit-rate reduced coding decisions
pass through a convenient separate channel such as one or more audio
channels. An alternative is to use the bit-rate reduction of the coding
decisions to enable them to be embedded in the video signal in a more
robust manner, such that they can be recovered without errors.

Where the chosen channel has insufficient capacity to support
sending the coding decisions with fixed length codewords, variable length
coding can be used. However, use of variable length coding means that the
short-term bit-rate can exceed that which fixed-length coding would give, and
some method of reducing this is required.

This invention, in one aspect, provides for decisions to be modified to
reduce their bit-rate whilst signaling to the recoder that the decisions have
been changed and so no longer correspond to the original bitstream.

Another aspect of this invention addresses the problem that where an
information bus is embedded in a video signal, it is not possible to detect
where parts of the picture have been changed by caption insertion,
cross-fades, and the like.

Another embodiment of this invention can be used for converting
between an information bus embedded in the video signal and a
side-channel based information bus. This would be typically used for
integrating a DCT-based VTR into an ITU-R Rec. 656 infrastructure.

On embodiment of this invention consists in a system for producing a
bit-rate reduced representation of coding decisions suitable for passing
through a channel (comprised of e.g. one or more audio channels) in which

the available bit-rate may be insufficient to carry the coding decisions themselves. Preferably, variable length coding of the information is employed.

The following are examples of this aspect of the invention:-

5   A.   An MPEG-compliant video bitstream, with "dummy" coefficients and coded block patterns inserted to keep the bitstream legal. These would not represent the coefficients and coded block patterns used for the original bitstream, but would give the shortest legal codewords.

B.   A bitstream that uses a modified version of the MPEG

10   format in which the macroblock syntactical element is altered so that it no longer includes coefficients or a coded block pattern. This would mean a small change in the way in which the bitstream is decoded.

C.   As form B. but in addition, some of the coding decisions, in particular the motion vectors, are coded in a non-compliant way in order to

15   reduce their bit-rate. Depending on how this is done (methods for this are described below), there may be a small or a large change to the way in which the bitstream is decoded.

The invention will now be described by way of example with reference to the accompanying drawings, in which:-

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Figure 1 shows a system according to this invention in which an MPEG bitstream is decoded for passage through a video channel to a encoder, with coding decisions being taken from the decoder and bit-rate reduced for passage through an information stream channel which

25   accompanies the video channel to the encoder;

Figure 2 illustrates a modification in which coding decisions are extracted from the MPEG bitstream, in front of the decoder; and

30   Figure 3 shows a system according to the invention in which coding decisions embedded in a video signal (in accordance with co-pending

international patent application PCT/GB97/01862) are extracted before the video signal passes through – for example – a digital VTR.

Referring initially to Figure 1, this shows a system in which an MPEG bitstream is decoded in MPEG-2 decoder (10) to produce a Rec. 656 video signal and a separate output of coding decisions, that are extracted from the bitstream. The latter would be typically take the form of an "Information Bus" as described in EP-A-0 766 576. The coding decisions, in particular the motion vectors, if necessary are then modified (as described below) in the modify decisions block (12) to reduce the number of bits required to code them. They are then variable length coded in VLC (14) using one of the above forms. Additional information can be added through to signal whether modification was performed. The resulting bitstream is then buffered in buffer (18) to form an Information Stream. This is then adapted to the particular channel (for instance it may be multiplexed between a number of audio bitstreams which are sent to an audio recorder). The level of the buffer (18) is sent back to block (12) to control the modification process and hence the short-term bit-rate entering the buffer.

After passing through the Information Stream channel (20) and subsequent buffering in buffer (24), the Information Stream passes to a VLD (26). The Information Stream channel (20) accompanies the video channel (22) which would typically include equipment such as a VTR. The decoded Information Stream can then be used by an MPEG encoder (28) whose input is the output of the video channel. Where the Information Stream contains information signalling that the coding decisions have been modified, the encoder may then remake some or all of the decisions.

There a number of possible options for modifying the coding decisions to reduce the number of bits required to code them:

1. Macroblocks can have up to four motion vectors, depending on the type of prediction and motion compensation employed. Fewer, or no, motion

vectors can be sent (this will require changes to other MPEG syntactical elements: macroblock_type and motion_type).

2. Motion vectors are coded differentially in MPEG, using a set of predictors that can be updated on a macroblock rate. The number of bits required to code a given motion vector increases with the size of the corresponding differential. Therefore motion vectors with large differentials can be modified to have a smaller differential, including the case of zero differential.

3. The MPEG syntax contains picture rate elements that specify the horizontal and vertical ranges of motion vectors that will appear in the forthcoming picture (the f_code values). The value of these affect how many bits are used to code the (differential) motion vectors. By employing options 1 and/or 2, it may be possible to modify the f_code values and code the remaining motion vectors in fewer bits.

4. There is an overhead (6 bits) where the quantisation step parameter changes between adjacent macroblocks. By changing the quantisation step parameters to be the same, this overhead is removed.

In addition there are refinements concerning when to employ the above techniques, in order to minimise the number of macroblocks that must be modified to save a given number of bits in the Information Stream. The purpose of doing this is to maximise the amount of video signal that can be recoded transparently:

1. B-pictures can use bi-directional prediction and so tend to require more bits for their coding decisions, especially motion vector bits. Because of this, and also because any loss in transparency on recoding is not propagated to other pictures, macroblocks in B-pictures should typically be modified with higher priority than those in other types of picture.

2. Macroblocks around the edges of the picture should have higher priority than those nearer the centre, because loss of transparency is less likely to be noticed around the edges.

3. By "looking ahead" a number of macroblocks, it may be possible to "spot" sequences of macroblocks that would give a good bit-rate saving.

When modification is performed, one or more of the following methods can be used of conveying this information:

1. One or more new syntactical elements are added to the bitstream. This method is not possible for form A of the Information Stream (the MPEG-compliant form).

2. Unused values of certain syntactical elements can be used. In particular, removing the coefficients from the syntax removes the need the "Not coded" values of macroblock_type. These can be reused to indicate that the decisions have been modified. This method is not possible for form A of the Information Stream.

3. For form A only, the information can be conveyed in the choice of the dummy values of the coefficients and/or coded block patterns inserted to keep the Information Stream as a legal MPEG bitstream.

4. User data is used.

For form C of the Information Stream, non-compliant coding is used to give greater reduction in bit-rate. Examples of methods to do this include:

1. A more complex motion vector predictor is used, for instance a two dimensional predictor that takes account of the vectors used in the

macroblocks above the current one as well as the macroblock to the left of it.

2. A model is calculated for the picture, or a portion of it, that provides a simplified description of a coding decision. Typically user data would be used to send the model at the start of the picture. Macroblock-rate information is used to describe deviations from this model. For motion vectors, the model can be considered as an advanced predictor.

3. Techniques such as quadtree coding are suitable for decisions that only have a relatively small number of possible values, such as macroblock type, motion type and DCT type. Quadtree coding can also be used to code vectors that appear in a "menu" – and reference is directed in this regard to GB 2240005.

All the above methods can be extended to allow modification of the coding decisions where necessary, and again any modifications could be signalled in the Information Stream.

An enhancement to the system described here is shown by the dotted lines in Fig 1. Information is added to the Information Stream, typically as user data, that gives information about the decoded video signal. When the Information Stream is decoded, the information can be checked against the video to be recoded. This will enable the recoder to make new coding decisions where the video signal has been changed substantially, for instance where captions have been added. Typically the information would be a macroblock-rate checksum (calculated in block (16) and compared in block (30)) if the video channel is transparent, or a macroblock-rate measure of mean and variance, if the video channel is not transparent (e.g. when it passes through a VTR). Statistical measures other

than mean and variance can be employed, and can be calculated on picture regions other than macroblocks.

A variant of the invention is shown in Fig 2, where blocks serving the same function as blocks in Fig 1 are given the same reference numeral and

5   not described further. In Fig 2, rather than coding the Information Stream from the decisions extracted from the bitstream, the MPEG codewords representing the decisions are stripped out and passed to block (50) with changes made as required where there is a need to modify decisions or add additional information. The "modify bitstream" block (50) thus serves an

10   analogous function to "modify decisions" block (12), although operating on variable length coded representations of the coding decisions, rather than the coding decisions themselves.

Another variant is shown in Fig 3. Here, an Information Stream that is embedded in a video signal (as mentioned above and as described in

15   PCT/GB97/01862) is converted into one of the formats described, and back again. This is suitable for adapting a VTR etc. into an infrastructure which otherwise employs an embedded Information Stream. More specifically, Fig 3 shows a block (60) which serves to extract an embedded information bus from an incoming video signal. The extracted information bus is

20   modified and variable length coded in the same manner as shown in Fig 1, to pass through an Information Stream channel 20. Downstream of the restricted video channel 22, the Information Stream is variable length coded for re-embedding in the video signal at block 62.

CLAIMS

1. A video compression system in which an encoder operates on a video signal and takes coding decisions in a compression encoding process to generate an encoded signal and in which a decoder operates on the encoded signal in a compression decoding process to generate an decoded signal, wherein a representation of coding decisions is provided in bit-rate reduced form and accompanies the decoded signal through a bit-rate reduced channel.

2. A video compression system according to Claim 1, wherein the bit-rate reduced representation of the coding decisions is passed through one or more audio channels accompanying a video channel carrying the decoded video signal.

3. A video compression system according to Claim 1, wherein bit-rate reduction of the representation of the coding decisions, comprises variable length coding.

4. A video compression system according to Claim 1, wherein short term control over bit-rate is achieved through modification of the coding decisions.

5. A video compression system according to Claim 1, wherein the bit-rate reduced representation of the coding decisions comprises an MPEG-compliant video bitstream.

6. A video compression system according to Claim 5, wherein the bit-rate reduced representation of the coding decisions comprises an MPEG-compliant video bitstream in which the coefficients and coded block patterns used for the original bitstream are replaced by with dummy coefficients and coded block patterns.

7. A video compression system according to Claim 1, wherein the bit-rate reduced representation of the coding decisions comprises an non-compliant MPEG video bitstream in which the coefficients and coded block patterns used for the original bitstream are deleted with alteration of the macroblock syntactical element.

8. A video compression system according to Claim 4, wherein modification of coding decisions comprises modification of motion vectors.

9. A video compression system according to Claim 8, wherein modification of coding decisions comprises modification of motion vectors where the differential is greater than a certain size.

10. A video compression system according to Claim 4, wherein modification of coding decisions includes looking ahead to find groups of macroblocks to be modified.

11. A video compression system according to Claim 4, wherein modification of coding decisions consists in preferential modification of B-frames.

12. A video compression system according to Claim 4, wherein modification of coding decisions consists in preferential modification around the edges of the picture.

13. A video compression system according to any one of the preceding claims, in which information about the decoded video signal is carried in said representation to enable detection of changes in the decoded video is changed.

14. A video compression system according to Claim 13, wherein said information about the decoded video signal comprises a check sum of a macroblock or other picture region.

5   15. A video compression system according to Claim 13, wherein said information about the decoded video signal comprises statistical information.

16. A video compression system according to Claim 15, wherein said
10   information comprises the mean and variance of a macroblock or other picture region.

The Patent Office

Application No:	GB 9801380.8	**Examiner:**	John Donaldson
Claims searched:	1 to 16	**Date of search:**	20 May 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

    UK Cl (Ed.P): H4F(FRC, FRD, FRG, FRM, FRP, FRR, FRS, FRT, FRW, FRX)

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Other: Online:WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	EP 0539833 A2 (IBM), see page 6, lines 45 to 54	-

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.